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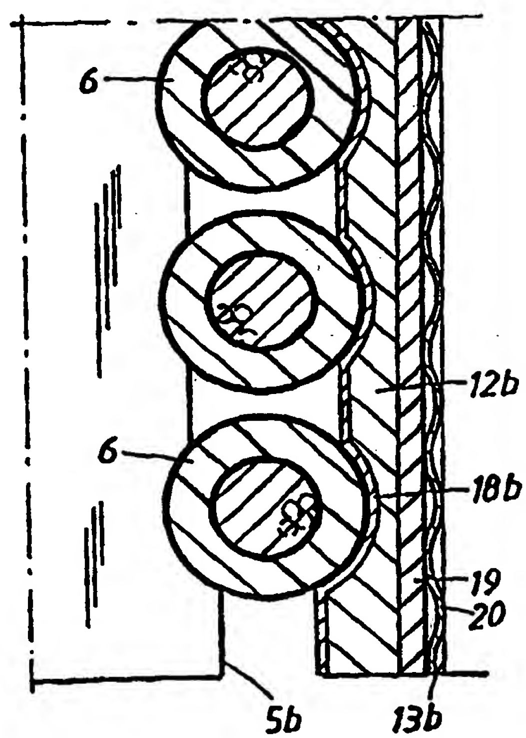
(57) Abstract

The invention relates to a rotating electric high-voltage machine. The machine is preferably intended for connection directly to the power network without any intermediate transformer. The stator windings comprise high-voltage cables arranged in radial slots in the stator core. In order to position the high-v ltage cables in the slots and to allow for their expansion in diameter, radially running pressure and resilient members are arranged in the slots.



ROTATING ELECTRICAL MACHINE COMPRISING HIGH-VOLTAGE STATOR WINDING AND RADIALLY EXTENDING SUPPORT DEVICES MOUNTED IN RADIALLY EXTENDING RECESSES IN THE STATOR SLOTS AND METHOD FOR MANUFACTURING SUCH MACHINE

The present invention relates in a first aspect to a rotating electric machine of the type described in the preamble to claim 1, e.g. synchronous machines, normal asynchronous machines as well as dual-fed machines, applications in asynchronous static current converter cascades, outerpole machines and synchronous flow machines.

A second aspect of the invention relates to a method of the type described in the preamble to claim 30.

The machine is intended primarily as a generator in a power station for generating electric power. The machine is intended to be used at high voltages. High voltages shall be understood here to mean electric voltages in excess of 10 kV. A typical operating range for the machine according to the invention may be 36 to 800 kV.

Similar machines have conventionally been designed for voltages in the range 6-30 kV, and 30 kV has normally been considered to be an upper limit. This normally implies that a generator is to be connected to the power network via a transformer which steps up the voltage to the level of the power network, i.e. in the range of approximately 100-400 kV.

By using high-voltage insulated electric conductors, in the following termed cables, with solid insulation similar to that used in cables for transmitting electric power in the stator winding (e.g. XLPE cables) the voltage of the machine may be increased to such levels that it can be connected directly to the power network without an intermediate transformer.

This concept generally implies that the slots in which the cables are placed in the stator be deeper than conventional technology requires (thicker insulation due to higher voltage and more turns in the winding). This entails new problems with regard to cooling, vibrations and natural frequencies in the region of the coil end, teeth and winding.

Securing the cable in the slot is also a problem - the cable must be inserted into the slot without its outer layer being damaged. The cable is subjected to currents having a frequency of 100 Hz which cause a tendency to vibration and, besides manufacturing tolerances with regard to the outer diameter, its dimensions will also vary with variations in temperature (i.e. load variations).

Although the predominant technology when supplying current to a high-voltage network for transmission, subtransmission and distribution, involves inserting a transformer between the generator and the power network as mentioned in the introduction, it is already known that attempys are being made to eliminate the transformer by generating the voltage directly at the level of the network. Such a generator is described in US-4 429 244, US-4 164 672 and US-3 743 867.

The manufacture of coils for rotating machines is considered possible with good results up to a voltage range of 10-20 kV.

Attempts at developing a generator for voltages higher than this have been in progress for some time, as is evident from "Electrical World", October 15 1932, pages 524-525, for instance. This describes how a generator designed by Parson 1929 was constructed for 33 kV. A generator in Langerbrugge, Belgium, is also described which produced a voltage of 36 kV. Although the article also speculates on the possibility of increasing the voltage levels, development of the concepts upon which these generators were based ceased. This was primarily due to deficiencies in the insulating system where several layers of varnish-impregnated mica foil and paper were used.

Certain attempts at lateral thinking in the design of synchronous generators are described in an article entitled "Water-and-oil-cooled Turbogenerator TVM-300" in J. Elektrotechnika, No. 1 1970, pages 6-8 of US 4,429,244 "Stator of generator" and in Russian patent specification CCCP Patent 955369.

The water-and-oil-cooled synchronous machine described in J. Elektrotechnika is intended for voltages up to 20 kV. The article describes a new insulation system consisting of oil/paper insulation which enabled the stator to be completely immersed in oil. The oil can then be used as coolant at the same time as constituting insulation. A dielectric oil-separating ring is provided at the internal

surface of the core to prevent oil in the stator from leaking out towards the rotor. The stator winding is manufactured from conductors having oval, hollow shape, provided with oil and paper insulation. The coil sides with the insulation are retained in the slots with rectangular cross-section by means of wedges. Oil is used as coolant both in the hollow conductors and in cavities in the stator walls. However, such cooling systems necessitate a large number of connections for both oil and electricity at the coil ends. The thick insulation also results in increased radius of curvature of the conductors which in turn causes increased size of the coil overhang.

The above-mentioned US patent relates to the stator part of a synchronous machine comprising a magnetic core of laminated plate with trapezoid slots for the stator winding. The slots are stepped since the need for insulation of the stator winding is less in towards the rotor where the part of the winding located closest to the neutral point is situated. The stator part also includes dielectric oil-separating cylinders nearest the inner surface of the core. This part will increase the excitation requirement in comparison with a machine lacking this ring. The stator winding is manufactured from oil-saturated cables having the same diameter for each layer of the coil. The layers are separated from each other by means of spacers in the slots and secured with wedges. Characteristic of the winding is that it consists of two "half-windings" connected in series. One of the two half-windings is situated centrally inside an insulating sheath. The conductors of the stator winding are cooled by surrounding oil. A drawback with so much oil in the system is the risk of leakage and the extensive cleaning-up process required in the event of a fault condition. The parts of the insulating sheath located outside the slots have a cylindrical part and a conical screening electrode whose task it is to control the electrical field strength in the area where the cable leaves the plate.

It is evident from CCCP 955369 that in another attempt at increaseing the rated voltage of a synchronous machine, the oil-cooled stator winding consists of a conductor with insulation for medium-high voltage, having the same dimension for all layers. The conductor is placed in stator slots in the shape of circular, radially situated openings corresponding to the cross-sectional area of the conductor and place required for fixation and cooling. The various radially located layers of the winding are surrounded and fixed in insulating tubes. Insulating spacer elements fix the tubes in the stator slot. In view of the oil

cooling. an inner dielectric ring is also required here to seal the oil coolant from the inner air gap. The construction illustrated shows no stepping of the insulation or of the stator slots. The construction shows an extremely narrow, radial waist between the various stator slots, entailing a large slot leakage flow which greatly affects the excitation requirement of the machine.

In a report from the Electric Power Research Institute, EPRI, EL-3391, from April 1984 an ewposition is given of the generator concept in which a higher voltage is achieved in an electric generator with the object of connecting such a generator to a power network without intermediate transformers. The report deems such a solution to offer satisfactory gains in efficiency and financial advantages. The main reason that in 1984 it was considered possible to start developing generators for direct connection to the power network was that by that time a suprerconducting rotor had been developed. The considerable excitation capacity of the suprerconducting field makes it possible to use air-gap windings with sufficient thickness to withstand the electric stresses.

By combining the constructing of an excitation circuit, the most promising concept of the project, together with winding, a so-called "monolith cylinder armature", a concept in which two cylinders of conductors are enclosed in three cylinders of insulation and the whole structure is attached to an iron core without teeth, it was deemed that a rotating electric machine for high voltage could be directly connected to a power network. This solution implied that the main insulation had to be made sufficiently thick to withstand network-to-network and network-to-earth potentials. Besides it requiring a superconducting rotor, an obvious drawback with the proposed solution is that it requires a very thick insulation, thus increasing the size of the machine. The coil ends must be insulated and cooled with oil or freones in order to direct the large electric fields in the ends. The whole machine is to be hermetically enclosed to prevent the liquid dielectric medium from absorbing moisture from the atmosphere.

It is also known, e.g. through DE 4 233 558, to arrange support members for the winding in a rotating electric machine, but not in connection with windings in which the insulation system is specially designed to permit extremely high voltages.

It is already known to arrange a hose filled with hardened epoxy between the bundle of cables in a slot and an aperture at the opening of the slot, which compresses the cables in radial direction towards the bottom of the slot. The contact between the cables provides a certain lateral fixation as well. However, such a solution is not possible when the cables are arranged apart from each other in the slot. Furthermore the lateral securing force is relatively limited and no adjustment to variations in diameter is achieved. This construction cannot therefore be used for high-voltage cables of the type used in the machine according to the present invention.

The present invention is related to the above-mentioned problems associated with avoiding damage to the surface of the cable during insertion into the stator slots and to avoid wear against the surface, resulting from vibration during operation. The slot through which the cable is inserted is relatively uneven or rough since in practice it is extremely difficult to control the position of the plates sufficiently precisely to obtain a perfectly uniform surface. The rough surface has sharp edges which may shave off parts of the semiconductor layer surrounding the cable. This leads to corona and break-through at operating voltage.

When the cable is placed in the slot and adequately clamped there is no risk of damage during operation. Adequate clamping implies that forces exerted (primarily radially acting current forces with double mains frequency) do not cause vibrations that cause wear on the semiconductor surface. The outer semiconductor is thus to be protected against mechanical damage even during operation.

During operation the cable is also subjected to thermal loading so that the PEX material expands. The diameter of a 145 kV XLPE cable, for instance, increases by about 1.5 mm at an increase in temperature from 20 to 70°C. Space must therefore be allowed for this thermal expansion. XLPE = cross-linked polyethylene .

Against this background the object of the present invention is to solve the problems of achieving a machine of the type under consideration so that the cable is not subjected to mechanical damage during winding or operation as a result of vibrations, and which permits thermal expansion of the cable. Achieving this

would enable the use of cables that do not have a mechanically protecting outer layer. In such case a the outer layer of the cable consists of a thin semiconductor material which is sensitive to mechanical damage.

According to the invention this has been solved by giving a machine of the type described in the preamble to claim 1 the special features defined in the characterizing part of the claim and by giving the method of the type described in the preamble to claim 30 the special features defined in the characterizing part of this claim.

In the present application the terms "radial", "axial" and "peripheral" constitute indications of direction defined in relation to the stator of the machine unless expressly stated otherwise.

Arranging radial support members in the slot walls in this way, secures the cable and provides it with support at these points. Selecting a suitable distance between these points ensures that the vibrations do not generate natural frequencies in the critical range around 100 Hz.

According to a preferred embodiment the semiconducting layer has the same coefficient of thermal expansion as the solid insulation, thereby avoiding defects, cracks and the like appearing at thermal movement in the cable.

In a preferred embodiment the support members are arranged in recesses in the slot walls.

In a preferred embodiment of the invention at least one, preferably every cable support member is in the form of a common support element for a plurality of cable parts in the slot. In this case it is particularly suitable for them to be common to all cable parts in the slot, and thus acquire a radially directed rod-like shape. The support force can then be applied jointly to all the cable parts with which the support element is in contact.

The support element preferably has a profiled surface towards the cable parts, which provides better support since the surface area in contact with each cable part is larger.

The surface of the support element facing the cable parts is suitably coated with an elastic material. If sufficiently thick, this elastic layer can completely absorb thermal expansion of the cable. Alternatively it may be relatively thin in order to absorb only individual variations between expansion of the cable parts, whereas most of the expansion is absorbed in some other way. The rubber layer eliminates the risk of the corners that may appear when the support element has a profiled surface, damaging the outer semiconductor layer of the cable.

In yet another preferred embodiment, the support element is provided with adjustment members for radial displacement. When the support element is profiled, this enables a securing force to be easily achieved against each cable part by radial displacement of the support member.

In yet another preferred embodiment the support element is common to two adjacent slots, the recesses then being so deep that they form a common slit connecting the slots, in which the support element is arranged. The number of support elements required may then be reduced.

In yet another preferred embodiment of the invention the support elements are pressed against the cable parts by means of a wedge. This offers favourable direction of the clamping force which will then be directed substantially in peripheral direction.

In yet another preferred embodiment spring members are arranged at the support member to press this towards the cable parts, thereby providing a simple and expedient method of taking up the thermal expansion of the cable.

According to yet another preferred embodiment the support member comprises spring members and pressure members.

The elongate pressure members running perpendicular to the cable parts fix these in the slots and the spring members allow for the absorption of a certain degree of change in the diameter of the cable. An important condition is thus created for achieving a machine with high-voltage cables in the windings at a voltage level

that permits direct connection to the power network without an intermediate transformer.

In yet another advantageous embodiment the pressure elements comprise a hose, filled with a pressure-hardened material, preferably epoxy. An expedient and reliable type of pressure element is thus obtained, which is simple to apply.

In another advantageous embodiment of the invention the pressure elements consist of a hose filled with a pressurized fluid, e.g. a liquid or a gas. The required pressure is thus achieved as well as a certain resilience in the clamping, thanks to the fluid.

Radially running channels are suitably provided in one or both side walls of the slot and the pressure elements are arranged embedded in these channels. The space required for securing is thus reduced to a minimum. The space thus saved is filled by the core instead and may be utilized.

When the pressure elements are in the form of hoses arranged in channels it may be suitable for the hose to run backwards and forwards in each channel. The pressure elements can thus be in the form of a continuous hose where the hose parts in each channel are connected together at the openings to the slots. This allows for easy assembly of the pressure elements.

The advantageous embodiments of the machine according to the invention mentioned above, and others, are defined in the dependent sub-claims to claim 1.

Thanks to the method according to the invention, a machine having the advantages related to a machine of the type defined in claim 1 may be produced simply and in an economically favourable manner. The measures to actively apply a force that presses against the cable parts via the cable support member, offer a particularly advantageous method of securing the cables.

In preferred alternative embodiments of the method according to the invention, the force is applied by the cable support member being displaced radially or by a wedge arranged close to the cable support member being displaced. These different alternatives have different advantages from different aspects. Their

advantages have been partially addressed in connection with the description of the various embodiments of the machine according to the invention, and will become more apparent from the detailed description.

The above mentioned and other preferable embodiments of the method according to the invention are claimed in the of the patent claim 30 dependent claims.

The invention is explained in more detail in the following description of preferred embodiments, with reference to the accompanying drawings in which;

Figure 1 shows schematically an end view of a sector of the stator in a machine according to the invention,

Figure 2 shows a cross-section through a conductor used in the machine according to the invention,

Figure 3 is a partial section through a stator sector illustrating a first and a second embodiment of the invention,

Figure 4 illustrates a detail in Figure 3,

Figure 5 is a partial section through a stator sector illustrating a third embodiment of the invention,

Figure 6 illustrates a detail in Figure 5,

Figure 7 shows schematically an axial partial section through a stator slot according to a fourth embodiment of the invention,

Figure 8 is a section along the line III-III in Figure 7,

Figure 9 is a section corresponding to that in Figure 7, but illustrating a fifth embodiment of the invention,

Figure 10 is a section along the line V-V in Figure 9,

Figure 11 is a section along the line VI-VI in Figure 9,

In this axial view shown schematically in Figure 1 through a sector of the stator 1 of the machine, its rotor is designated 2. The stator is composed in conventional manner of a laminated core of sheet steel. The figure shows a sector of the machine corresponding to one pole division. From a yoke portion 3 of the core situated radially outermost, a number of teeth 4 extend radially in towards the rotor 2 and are separated by slots 5 in which the stator winding is arranged. The cables 6 in the windings are high-voltage cables which may be of substantially the same type as high-voltage cables used for power distribution, so-called XLPE cables. One difference is that the outer mechanically protective sheath that normally surrounds such a cable has been eliminated so that the cable comprises only the conductor, an inner semiconductor layer, an insulating layer and an outer semiconducting layer. The semiconductor layer, sensitive to mechanical damage, is thus exposed on the surface of the cable.

In the drawings the cables 6 are illustrated schematically, only the conducting central part of the cable part or coil side being drawn in. As can be seen, each slot 5 has varying cross-section with alternating wide parts 7 and narrow parts 8. The wide parts 7 are substantially circular and surround cable parts, and the waist parts between these form narrow parts 8. The waist parts serve to radially position each cable part. The cross section of the slot as a whole also becomes slightly narrower in radial direction inwards. This is because the voltage in the cable parts is lower the closer they are situated to the radially inner part of the stator. Slimmer cable parts can therefore be used here, whereas increasingly coarser cable parts are required further out. In the example illustrated cables of three different dimensions are used, arranged in three correspondingly dimensioned sections 9, 10, 11 of the slots 5.

Figure 2 shows a cross-sectional view of a high-voltage cable 6 according to the present invention. The high-voltage cable 6 comprises a number of strands 31 of copper (Cu), for instance, having circular cross section. These strands 31 are arranged in the middle of the high-voltage cable 6. Around the strands 31 is a first semiconducting layer 32, and around the first semiconducting layer 32 is an insulating layer 33, e.g. XLPE insulation. Around the insulating layer 33 is a second semiconducting layer 34. Thus the concept "high-voltage cable" in the

present application need not include the metallic screen and the outer protective sheath that normally surround such cables for power distribution.

Figure 3 illustrates two alternative embodiments of the support member. On the right of the figure is a support member designed as a single-acting support element 12 and on the left as a double-acting support element 12a.

In corresponding manner to Figure 1, the stator 1 is provided with a number of slots 5 having profiled slot walls. In the slot 5 to the right in the figure a recess 13 is provided in its left wall. Similar recesses are provided in the slot with uniform axial spacing, about 2 - 5 per metre. Each recess has relatively short axial width, approximately 20-50 mm, and its bottom lies in a radial plane, as revealed in the figure. Since the slot wall is profiled the slot has varying depth. The support element 12 is arranged in the slot and has an axial extension some mm shorter than the recess 13 and a surface facing towards the slot wall that is profiled to fit the wall. The recess 13 continues radially outwards from the slot 5 as an aperture 14 through the outermost yoke portion 3. The support element 12 is provided with a control rod 15 extending through the aperture 14 and outside the surface of the stator. The rod 15 is threaded at its outer end to cooperate with a nut 16. When the nut 16 is tightened, the rod 15 and thus the support element 12 are drawn upwards. The support element 12 is thus pressed against the cable parts in the slot 5 and presses these against the slot walls so that the cable parts are firmly clamped to each support element 12. The pressure is adjusted to a suitable amount by judicious tightening of the nut 16.

In the embodiment illustrated to the left in the figure, the recess 13 is replaced by a slit 13a extending between two adjacent slots 5a, 5a'. A support element 12 with profiled support surfaces facing the cable parts in the two slots 5a, 5a' is arranged in the slit 13. The support element 12a is thus double-acting. An aperture 14a is provided mid-way between the slots 5a, 5a' for the control rod 15a of the double-acting support element 12a. Tightening the nut 16a causes application of pressure on the cable parts in the two adjacent slots 5a, 5a'. This embodiment also illustrates how the clamping can be made resilient in radial direction by means of a compression spring 17 arranged between the nut 16a and the outer surface of the stator 1. Such a compression spring may also be arranged in the embodiment shown to the right in the figure. Spacers 21 are arranged between the laminated

core sheets, axially on both sides of each support element 12a, the spacers 21 extending into oblong apertures 22 in the support element 12a, with radial play to allow for the radial movement of the support element 12a. The spaces prevent the support element 12a from being clamped fast.

Figure 4 shows a part of the support element 12 on a larger scale. It consists of a rigid material such as epoxy, glass, glassfibre laminate or steel, the support surface of which is coated with a layer 18 of elastic material such as rubber. According to one embodiment the rubber layer 18 has a thickness of about 0.5 mm in compressed state and is arranged to take up only individual variations in thermal expansion of the cable parts. Alternatively, the layer may have a thickness allowing it to take up the entire thermal expansion of the cable parts. In that case it should be 2 mm thick. Such an elastic layer may be arranged on the support surfaces even in the embodiment with double-acting support elements.

The embodiment shown in Figures 5 and 6 differs from those described earlier primarily in how the pressure on the cable parts is achieved. The outwardly directed aperture and control rod are missing here. Instead a thin, elongate wedge 19 is arranged between the support element 12b, abutting the surface facing away from the cable parts. The wedge 19 becomes narrower towards the outside, has a thickness of a few mm and a difference in thickness between its outer and inner ends of just over 1 mm. The wedge may be made of glassfibre laminate. When the wedge 19 is pushed into the recess 13b it will press against the support element 12b so that this will press the cable parts 6 with a substantially peripherally directed force, i.e. seen radially in relation to the cable part.

The wedge 19 may either support directly against the bottom of the recess 13b or, as illustrated in the embodiments according to Figures 5 and 6, against a spring element 20 arranged between the wedge 19 and the bottom of the recess 13b. The spring element 20 is illustrated as a corrugated laminate and is suitably in the form of a Krempel wave with glassfibre-reinforced plastic, e.g. polyester or epoxy as material. Its thickness is about 2 mm. The purpose of the spring element 20 is to absorb the thermal expansion of the cable parts and complements the, in this case, thin (0.5 mm) rubber layer 18b which takes up only individual variations in the expansion.

On the manufacture of a stator according to the drawings, the recesses in the slots are produced by the laminated sheets already having been provided with such recesses at these points. The support elements are then inserted radially from the inside into these recesses into the desired position. After that the cable is wound. When this has been done the support element is pressed against the cable parts in the slot by pulling the support element upwards as in Figure 3, or inserting a wedge behind the support element as shown in Figures 5 and 6.

Figure 7 shows in more detail a section through one of the slots 5, where an arrangement for the elastic fixation of the cable is illustrated. The slot is provided on one side with a number of radially running channels 112 in the slot wall. Each channel extends along the entire radial extension of the slot and is arranged at a suitable axial distance from the next one. The pressure and resilient member runs in the channel 112 and is in the form of a hose 113 filled with epoxy 115 which hardens under pressure and on one side of which a rubber strip 114 is applied. The rubber strip 114 is arranged between the hose 113 and the cable parts 6 and is pressed against the latter by the pressure-hardened epoxy 115 in the hose 113. This secures each cable part 6 in peripheral direction and the rubber strip 114 enables absorption of thermal expansion in the cable diameter.

Figure 8 shows a cross-section of the channel along the line III-III in Figure 7. Figure 8 shows the channel 112 immediately after the hose 113 has been fitted and before the hose has been filled with epoxy. As can be seen, it is flat which makes it easy to pull through the channel. Once in place, the hose is filled with epoxy under a pressure of approximately 1 MPa so that it swells and presses the rubber strip against the cable part 6, and is then allowed to harden at this pressure. At this pressure a force of approximately 1500-2000 N is obtained at each point where a hose and a cable cross each other, the cable dimension in question here, is approximately 60 mm. To secure the cable parts satisfactorily it is sufficient to arrange the hoses with spacing between them equivalent to approximately four times the cable diameter, i.e. with a pitch of approximately 250 mm. The channel is approximately 50 mm wide and has a depth of approximately 10 mm.

Figure 9 shows an alternative embodiment of the pressure elements. Instead of an epoxy-filled, rubber-coated hose, a hose 121 is used here which is filled with a pressurized fluid in liquid or gaseous form. The fluid pressure is approximately

1 MPa and gives a contact force of 1500-2000 N per cable/hose crossing. The fluid pressure provides both a positioning force and elastic yielding so that the rubber strip in the embodiment according to Figure 7 is superfluous.

Figure 10 shows a section through the channel 20 along the line V-V in Figure 9. In the embodiment according to this example two hose parts 121a, 121b are arranged in the same channel. The hose 121 runs into and out of the slot and its two parts are joined by means of a hose bend 121c furthest out in the bottom of the slot. This is illustrated in Figure 6. The hose 121 and channel 120 are joined together by connecting parts 121d of the hose which extend axially along the entire stator and are located close to the entrances to the slots 5 between a wedge 122 arranged there, and the winding turn situated radially innermost. The hoses in the channels in a slot are thus formed by a common hose which is connected to a pressure source to enable pressurization of the fluid in the tube.

Such a coherent arrangement of the hose may of course be utilized in the embodiment shown in Figures 7 and 8 where the hose is filled with pressure-hardened epoxy.

The invention can advantageously be combined with an embodiment in which each slot is lined. Figure 8 thus shows how a lining 117 of aramid fibre is arranged on the slot walls. In the embodiments in which the pressure elements are not arranged in channels, alternatively of arranging these outside the lining is also feasible, i.e. between the lining and the cable.

In the two embodiments described the pressure elements are arranged in channels. The advantages of this have been mentioned in the introductory part of the specification, but it should be obvious that the invention is applicable and offers considerable advantages even without special channels being provided in the slot wall.

CLAIMS

1. A rotating electric machine comprising a stator with windings (6) drawn through slots (5) in the stator (1), characterized in that at least one winding (6) comprises an insulation system comprising at least two semiconducting layers (32, 34), each layer essentially constituting an equipotential surface, and also including solid insulation (33) situated between these layers (32, 34) and in that radially directed support members (12, 114, 121) are arranged in contact with the windings in the slot (5).

2. A machine as claimed in claim 1, in which at least one of said layers (32, 34) has essentially the same coefficient of thermal expansion as the solid insulation (33).

3. A machine as claimed in claim 1 or claim 2, wherein the windings (6) consist of high-voltage cable and at least some of the slots (5) are provided with a plurality of radially directed recesses (13) in at least one side wall of the slot (5), in which recesses (13) the cable support members (12) are arranged.

4. A rotating electric machine as claimed in claim 3, wherein at least one cable support member (12) constitutes a support element common to a plurality of cable lead-throughs (6) arranged in a slot.

5. A rotating electric machine as claimed in claim 4, wherein at least one support element (12) is common to all cable lead-throughs (6) in the slot (5) and constitutes a radially directed elongated, rod-like element.

6. A rotating electric machine as claimed in claim 4 or claim 5, wherein at least one support element (12) has a side facing the cable leaad-throughs that is profiled with axially running depressions, each one arranged to support one cable part (6).

7. A rotating electric machine as claimed in any of claims 3-6, wherein at least one support element (12) has a side facing the cable lead-throughs that is coated with elastic material (18).

8. A rotating electric machine as claimed in claim 6, wherein at least one support element (12) is provided with adjustment members (15, 16) to adjust its position in radial direction.

9. A rotating electric machine as claimed in any of claims 3-8, wherein at least one support element (12) is secured to the stator (1) by means of radially directed spring members (17).

10. A rotating electric machine as claimed in any of claims 3-9, wherein a radially directed aperture (14) extends from at least one of said recesses (13) to the outside of the stator and wherein the support element (12) arranged in the recess (13) extends out through said aperture (14).

11. A rotating electric machine as claimed in any of claims 4-10, wherein at least one of said recesses has a depth in the peripheral direction of the stator (1) that it reaches the slot located nearest to it, thereby forming a slit (13a) connecting the two slots and wherein the support element (12a) constitutes a support element for the cable lead-throughs in both the adjacent slots (5a, 5a').

12. A rotating electric machine as claimed in any of claims 4-10, wherein a pressure member (19) is arranged to act on at least some support element (12b), said pressure member (19) being wedge-shaped.

13. A rotating electric machine as claimed in any of claims 4-12, wherein spring members (20) acting in peripheral direction of the stator are arranged at least one support element (12b) to press this against the cable lead-throughs (6).

14. A rotating electric machine as claimed in any of claims 3-13, wherein each slot (5) in a radial section through the stator (1) has a profile with alternate wide parts (7) and narrow parts (8) in radial direction.

15. A machine as claimed in claim 1 or claim 2, wherein said support members comprise means for resilientl securing of the cable parts in the slot, said means comprising pressure members acting on each cable part, arranged between the cable part and at least one side wall of the slot, and spring members arranged between the cable part and at least one side wall of the slot, said pressure members

consisting of a plurality of elongated pressure elements running in the radial direction of the slot.

16. A machine as claimed in claim 15, arranged for direct connection to a power network without intermediate transformers.

17. A machine as claimed in claim 15 or claim 16, in which said pressure elements of the pressure member are arranged with a mutual axial distance that is 3 to 5 times the diameter of the cable.

18. A machine as claimed in any of claims 15 to 17, wherein each of said pressure elements is in the form of a hose comprising a sleeve containing a pressure-hardened material.

19. A machine as claimed in claim 18, wherein said material is epoxy.

20. A machine as claimed in any of claims 15 to 17, wherein each of said pressure elements is in the form of a hose comprising a sleeve containing pressurized fluid.

21. A machine as claimed in claim 20, wherein said fluid is a liquid.

22. A machine as claimed in claim 20, wherein said fluid is in gaseous form.

23. A machine as claimed in any of claims 15-22, wherein at least some of said pressure elements are arranged in channels running radially in at least one wall of the slot.

24. A machine as claimed in any of claims 15-23, wherein said pressure elements on an axially directed surface are provided with spring members.

25. A machine as claimed in claim 24, wherein said spring members abut against said cable parts.

26. A machine as claimed in claim 21 or claim 25, wherein said spring members consist of a strip of elastic material secured to said pressure element.

27. A machine as claimed in claim 26, wherein said strip is provided with slits on the said of the strip facing away from the pressure element.

28. A machine as claimed in any of claims 18-27, wherein at least some of said hoses are arranged in channels running radially in one wall of the slot and wherein two parallel hose parts are arranged in each channel, joined together close to the bottom of the slot.

29. A machine as claimed in claim 28, wherein the hoses in one channel are joined with hoses in other channels.

30. A method of manufacturing a stator for a rotating electric machine in which a cable is drawn through slots in the stator to form stator windings, characterized in that a plurality of radially directed recesses are arranged in at least one wall in at least some of the slots, that cable support members are arranged in said recess, that thereafter a high-voltage cable is wound in the slots and that thereafter a force is applied which presses the cable support member against the cable lead-throughs.

31. A method as claimed in claim 30, wherein said force is applied by displacing the cable support member radially.

32. A method as claimed in claim 30, wherein a wedge is arranged at a surface of the support member facing away from the cable lead-throughs and that said force is applied by radial displacement of the wedge.

33. A method as claimed in any of claims 3-32, wherein at least one of said recesses has such a depth in the peripheral direction of the stator that it reaches the slot located nearest to it, so that a slit is formed connecting the two slots and wherein a cable support member is arranged in the slit for the cable lead-throughts in both the slots and wherein said force is applied so that it presses the cable support member against the cable lead-throughts in both slots.

34. A method as claimed in claim 30, wherein it is applied to a machine as claimed in any of claims 1-14.

Fig. 1

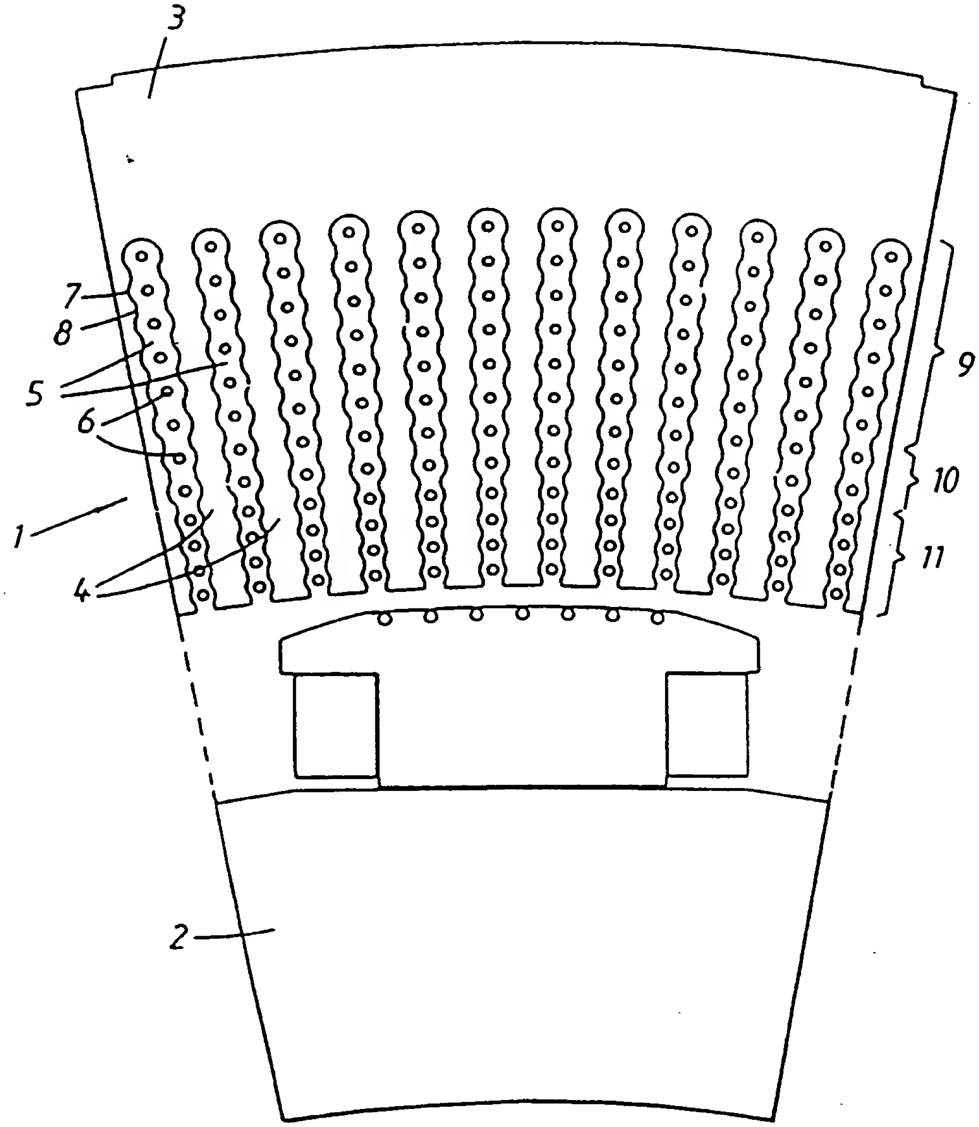


Fig. 2

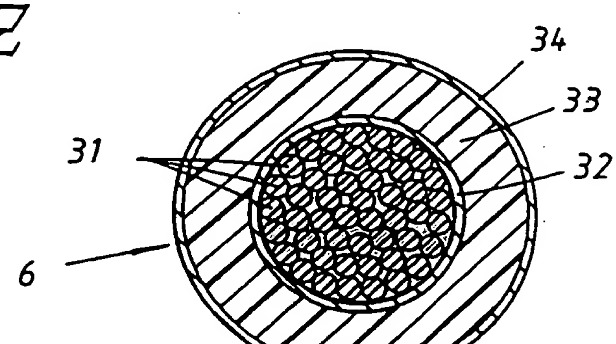


Fig. 3

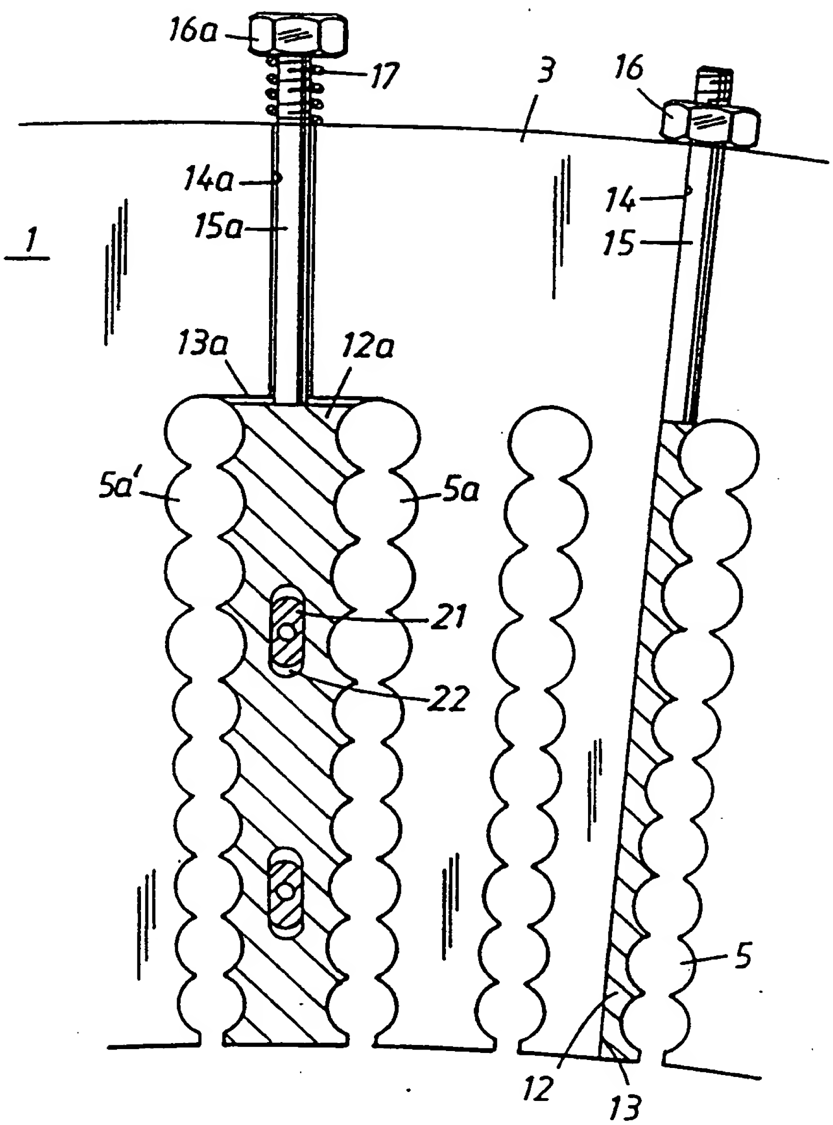


Fig. 4

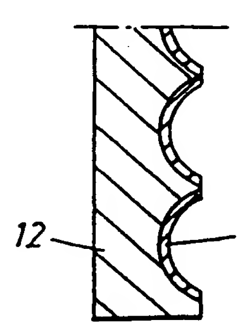


Fig. 5

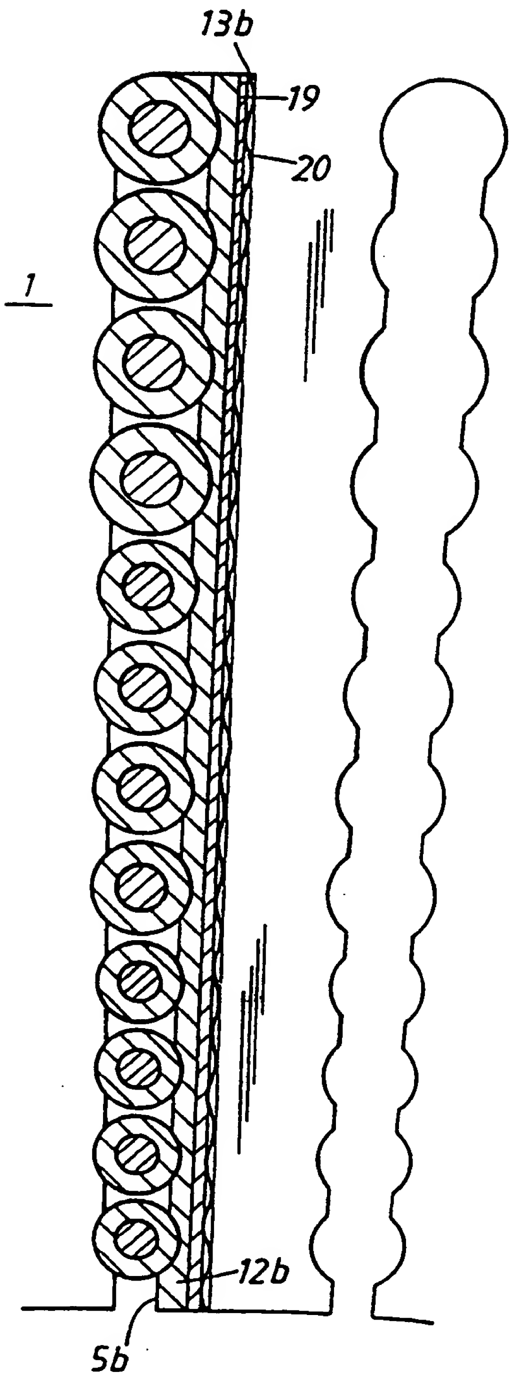


Fig. 6

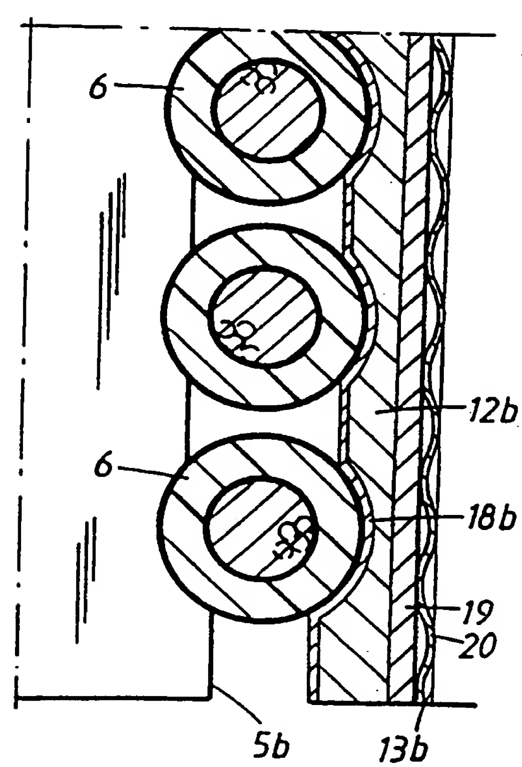


Fig. 7

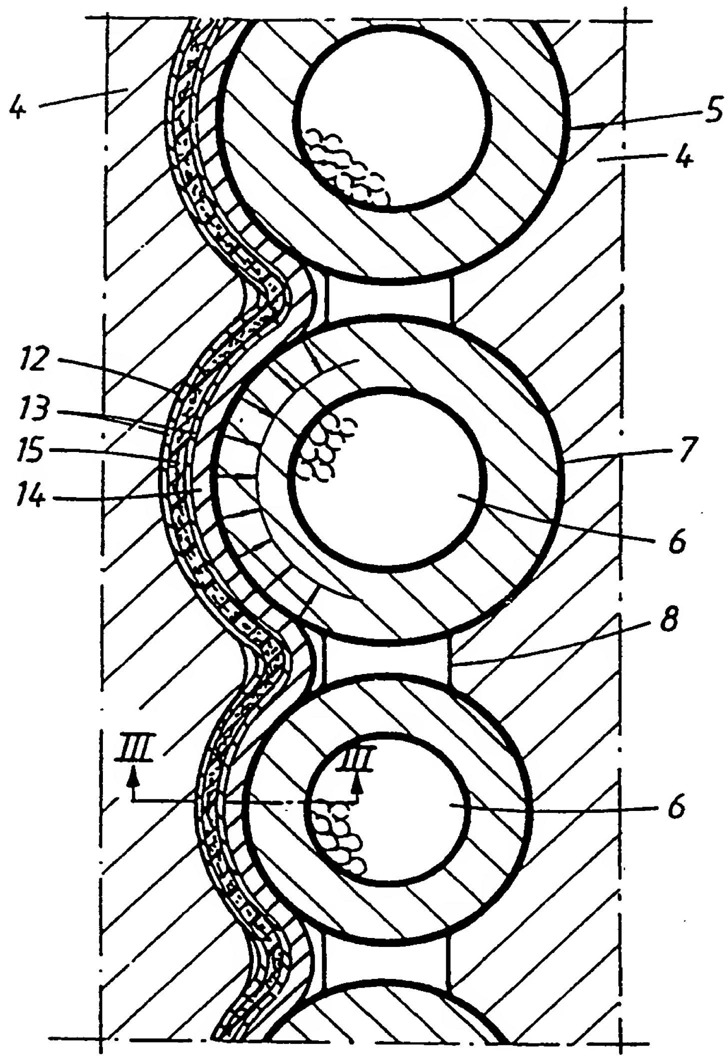


Fig. 8

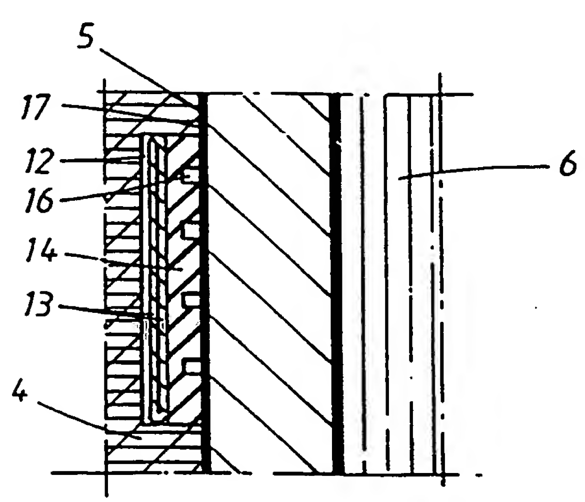


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Fig. 9

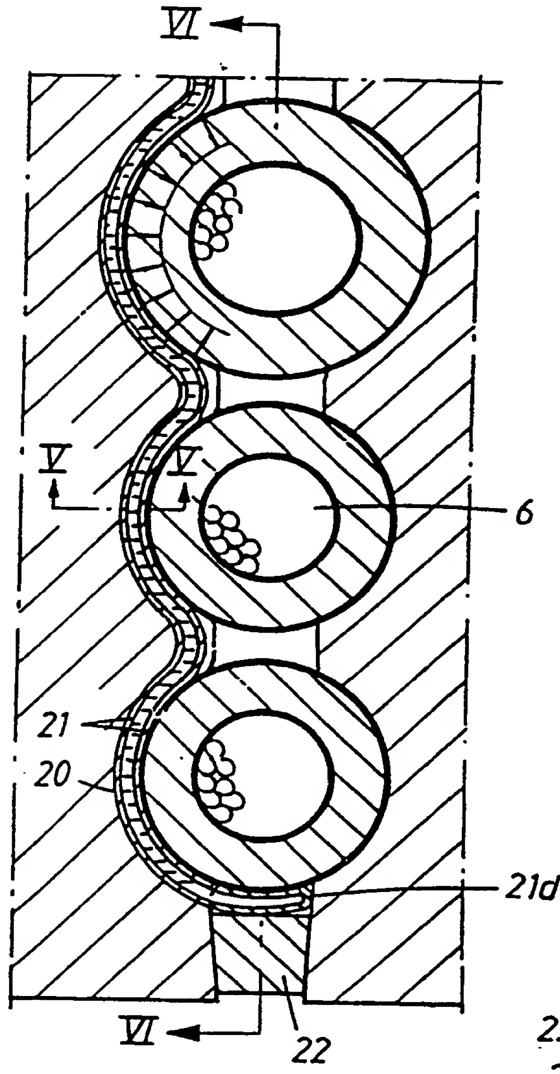


Fig. 10

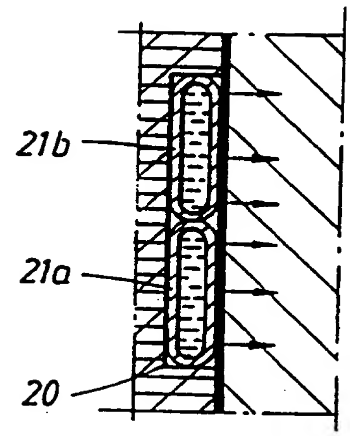
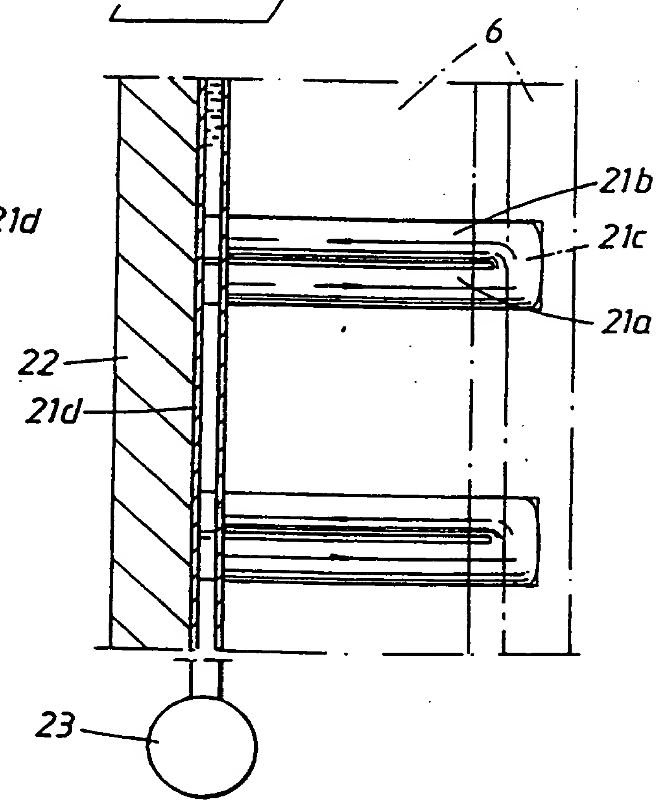


Fig. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00898

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 3/48, H02K 3/40, H02K 15/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5036165 A1 (R.K. ELTON ET AL.), 30 July 1991 (30.07.91), column 1, line 16 - line 60; column 2, line 26 - line 57, figure 1, abstract	1,2,15-22, 24-27
A		30-34
	--	
Y	GB 1135242 A (ASSOCIATED ELECTRICAL INDUSTRIES LIMITED), 4 December 1968 (04.12.68), page 1, line 17 - line 26; page 1, line 33 - line 61; page 1, line 73 - line 76, figures 2,3, page 2, line 1 - line 15; page 2,line 34 - line 36	15-22,24-27
A		3,12,23
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 1997	23 -10- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Håkan Sandh Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00898

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3932779 A1 (K.D. MADSEN), 13 January 1976 (13.01.76), abstract	18,19
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Y	US 3158770 A1 (A.D. COGGESHALL ET AL.), 24 November 1964 (24.11.64), column 1, line 70 - line 72; column 2, line 1 - line 7; column 2, line 40 - line 45, figures 1,2, column 2, line 67 - line 72	1,2
A		13,15
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A	SU 955369 A ((GIDR) SCI SECT GIDROPROEKT RES INST), 30 August 1982 (30.08.82), figures 1,2, abstract	14
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A	EP 0571155 A1 (MITSUBA ELECTRIC MFG. CO., LTD.), 24 November 1993 (24.11.93), abstract	2
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A	US 4281264 A1 (T.A. KEIM ET AL.), 28 July 1981 (28.07.81), column 2, line 10 - line 28; column 3, line 6 - line 44; column 4, line 56 - line 58, figures 1,2	5,8-11,30-34
	--	
A	US 4942326 A1 (J.M. BUTLER,III ET AL.), 17 July 1990 (17.07.90), column 3, line 27 - line 30, figure 2	7
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Y	US 4008409 A1 (R.G. RHUDY ET AL.), 15 February 1977 (15.02.77), column 3, line 16 - line 32; column 5, line 6 - line 33, figures 2-3	24-27
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INTERNATIONAL SEARCH REPORT

International application N .
PCT/SE 97/00898

Box I Observations where certain claims were found unsearchable (Continuation of item 1 f first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reas ns:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

I. Claims 1-29 describes a rotating electrical machine comprising a statorwinding featuring two semi-conducting layers with solid insulation in between, and radially extending support devices.

II. Claims 30-34 describes the manufacturing of a stator for a rotating electrical machine comprising statorwinding of high-voltage cable. Support devices are mounted in radially extending recesses in the stator slots.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted t the invention first mentioned in the laims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ N protest accompanied the payment of additi nal search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/10/97

International application No.
PCT/SE 97/00898

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5036165 A1	30/07/91	US 5066881 A	19/11/91
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		CN 1047175 A	21/11/90
		EP 0393836 A	24/10/90
		JP 2294243 A	05/12/90
US 4008409 A1	15/02/77	BR 7602220 A	05/10/76